Return to Flight Implementation Plan introduced

By Eldora Valentine and Kendra Ceule

In early September, NASA released its Return to Flight Implementation Plan, which serves as the Agency's blueprint for implementing the recommendations of the *Columbia* Accident Investigation Board. Frequently described as a "living document," the Implementation Plan will be updated periodically to reflect new progress and knowledge.

In the upcoming months, the *Roundup* will highlight sections of the Implementation Plan and what Johnson Space Center is doing to get the Shuttles flying again. Our series begins with a story on the Thermal Protection System (TPS) of the orbiters and the possibilities for on-orbit TPS repairs.

Andre Sylvester, lead for Future Inspection and Access Options, briefs the media at the Return to Flight Tile Repair Briefing in JSC's Space Environment Simulation Laboratory.

jsc2003e57022 Photo by James Blair

NASA Administrator Sean O'Keefe and JSC Director Jefferson D. Howell, Jr., watch Astronaut Scott Parazynski demonstrate the use of spacewalking tools during Return to Flight Implementation Task Group Activities at JSC's Space Environment Simulation Laboratory.

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Onboard a KC-135 aircraft, a team rehearses possible spacewalking techniques for repairing damaged Shuttle tiles.

jsc2003e52825 Photo by David DeHoyos

JSC leads the way in developing a Thermal Protection System repair process

An orange-colored "goop" could be the tile-repair solution that Shuttle engineers have been looking for.

The material, called MA-25S, is "showing promise in testing," said Paul Hill, STS-114 Lead Flight Director. Hill spoke on the topic during a Sept. 16 briefing on Thermal Protection System (TPS) repair efforts. The briefing was part of the Return to Flight Media Workshop held at Johnson Space Center.

If the sticky, silicon-based material were ever used to repair Shuttle tiles on orbit, astronauts would apply it with a device like a caulk gun and then smooth it out to reduce turbulence. However, the experts reiterated that the best line of defense against debris damage is to prevent it in the first place.

"The expectation is that we won't be repairing," Hill said. "But what you're hearing from me is that we're going to pound this flat and understand how to do it, and we will be ready to do it."

Hill was joined at the briefing by Steve Poulos, Space Shuttle Vehicle Engineering Office Manager; Fred Ouellette, Space Shuttle Vehicle Engineering Office Assistant Manager and Jose Hernandez, Aerospace Engineer, Structural Engineering Division. The panel outlined five levels of crew and orbiter protection that NASA is striving for:

- Eliminate or greatly minimize debris sources
- Develop and improve NASA's ability to inspect the orbiter for damage on orbit
- Define the impact tolerance of the TPS
- Develop TPS repair capabilities
- Evaluate the International Space Station for crew contingency options

While MA-25S is a standout possibility for repairing tile, there is currently no such frontrunner for the other part of TPS: the reinforced carbon-carbon (RCC) panels. The U-shaped RCC panels line the leading edge of Shuttle wings, giving them their aerodynamic shape and protecting the inside of the wing during reentry. A hole in one of these panels was determined to be the cause of the STS-107 accident.

"It's a challenge," said Bradley Files, Materials Engineer at JSC. "In May we started looking at ways to find a suitable plug to patch a hole" in RCC panels, he said. Files was on hand during a demonstration of potential TPS repair techniques for the media on Sept. 17.

One possible RCC repair method involves an "umbrella" device that would allow a patch to be inserted through a small hole and mechanically anchored to a damaged panel. Such an umbrella would be pushed through the hole, tightened with a bolt and backfilled with a heat-resistant caulk. Engineers are still looking at other materials and methods that could be used for larger damaged areas as well.

While RCC repair is still in the early stages of development, JSC experts remain optimistic about achieving a workable solution.

"While we haven't finished the RCC repair yet, we are seeing some things that are positive," Hill said. "Some of these things that we're doing, we didn't think were possible in February."

Q&A

How would astronauts get to the damage site to do repairs?

The first part of any on-orbit TPS repair is getting the astronaut to the site of the damage. While docked to the International Space Station, this would be a two-part task.

Part one would involve using the Shuttle's robot arm to grapple the Station and maneuver the vehicle into position. Then, astronauts would "use the ISS arm to 'cherry-pick' the EVA (or spacewalking) astronaut to various parts of the orbiter," Paul Hill, STS-114 Lead Flight Director, said. However, this method would not be a permanent solution because it would not be physically possible after the Station's Japanese Kibo module is attached.

For repairs away from the Space Station, Hill said, the crew would use a "boom" extension on the Shuttle's robot arm – currently under development – to carry an astronaut to the repair site.

When asked why the Simplified Aid for EVA Rescue (SAFER) could not be used for this task, Hill explained that while SAFER could carry an astronaut to the repair site for an up-close inspection, it would not function as an immobile workstation. Before making repairs, the spacewalking astronaut would need to be secured to the bottom of the vehicle – otherwise, "you'd be bouncing off, rotating up and generally causing more damage than you're repairing," he said.

Methods to secure a free-floating astronaut were investigated but shown to be more complex than using a boom/Shuttle-arm system.

How would astronauts repair damaged tiles?

One method researchers are using for tile-repair testing is called the "Under-fill Technique." This technique would work as follows:

- **First, the area of the damaged site is measured. A depth gauge is used to get a sense of the volume of repair needed.**
- **The dabbing of a sticky foam brush inside the cavity absorbs broken tile dust and prepares the surface for the silicon material.**
- **The silicon material, applied with a large device similar to a caulk gun, patches the hole.**
- **The astronaut uses a foam roller or foam brush to flatten peaks and high spots on the surface of the repair. After curing for 24 hours, the ablative goop will have hardened enough to protect the Shuttle during reentry.**

Astronauts including Scott Parazynski have been practicing the technique in the lab and aboard the KC-135, but he is eager to try it out in space. "It's going to be a challenging task," he said. "You have to be patient and precise to do this. This is an art form into itself. "

Parazynski said he thinks "the operation is coming together well. We have a talented team of engineers," he said. "But we still have work to do."

Extravehicular Activities (EVA) Operations Engineer Dina Barclay, right, participates in a suited evaluation of tile repair techniques in JSC's Space Environment Simulation Laboratory. EVA Operations Engineer Dana Weigel, left, conducts the evaluation and EVA Tools Engineer Lora Bailey assists.

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